Original papers

Can mobile technology improve response times of junior doctors to urgent out-of-hours calls? A prospective observational study

P.J.J. HERROD, C. BARCLAY and J.D. BLAKEY

From the 1Department of Orthopaedic Surgery, Sherwood Forest Hospitals NHS Trust, UK, 2Project lead for Hospital 24/7, Critical Care Outreach Team, University Hospitals of Leicester NHS Trust, Glenfield Hospital, Leicester LE3 9QP, UK and 3Clinical Sciences, Liverpool School of Tropical Medicine, Liverpool L3 5QA, UK

Address correspondence to Dr P.J.J. Herrod, Department of Orthopaedic Surgery, King’s Mill Hospital, Sutton in Ashfield, Nottinghamshire NG17 4JL, UK. email: pherrod@nhs.net

Received 19 September 2013 and in revised form 23 November 2013

Summary

Background: The Hospital at Night system has been widely adopted to manage Out-Of-Hours workload. However, it has the potential to introduce delays and corruption of information. The introduction of newer technologies to replace landlines, pagers and paper may ameliorate these issues.

Aim: To establish if the introduction of a Hospital at Night system supported by a wireless taskflow system affected the escalation of high Early Warning Scores (EWSs) to medical attention, and the time taken to medical review.

Design: Prospective ‘pre and post’ observational study in a teaching hospital in the UK.

Methods: Review of observation charts and medical records, and data extraction from the electronic taskflow system.

Results: The implementation of a technology-supported Hospital at Night system was associated with a significant decrease in time to documentation of initial review in those who were reviewed. However, there was no change in the proportion of those with a high EWS that were reviewed, and throughout the study a majority of patients with high EWSs were not reviewed in accordance with guidelines.

Conclusions: Introduction of a Hospital at Night system supported by mobile technology appeared to improve the transfer of information, but did not affect the nursing decision whether to escalate abnormal findings.

Introduction

Hospitals in the UK are struggling to cope with ever increasing numbers of admissions and falling bed numbers. These admissions are predominantly elderly patients with multiple medical problems. This pressure is most acute during the 75% of the year that does not fall between 9 AM and 5 PM Monday to Friday. During this ‘Out-of-Hours’ (OOH) period, care is largely provided by a skeleton staff of junior doctors, support workers and nurses.

The relatively junior OOH team must provide timely care for emergency admissions and acutely unwell patients on the wards while also supporting an increasing burden of new treatments such as acute stroke thrombolysis. Additionally, individual junior doctors’ hours have fallen by more than...
35% to comply with the European Working Time Directive. This has led to a move to a shift-based system, with increasing shift intensity and to problems of communication between shifts. These challenges are magnified by the increased stress, decreased support and fatigue when working OOH. Given these challenges, it is not surprising that mortality in hospitals is reproducibly higher at the weekend and overnight.

The Hospital at Night system was developed to provide OOH care in this demanding environment: requests for medical input are collated by a senior nurse coordinator who then distributes tasks to available medical and support staff. Hospital at Night has been widely adopted and appears to have some benefits. However, it does introduce an additional step in the transfer of information, leading to delays and potential data degradation. The use of newer information technology in place of pagers, landlines and paper jobs lists has the potential to ameliorate these concerns by speeding up the communication process and reducing error rates.

Early warning scores (EWSs) based on routine observations are commonly employed to alert the OOH team staff of doctors and nurses to deteriorating patients. Both local versions and the recently launched national version relate the score to a graded time-related response strategy. Although these scores are associated with improved outcomes overall, there is concern that response times remain suboptimal, a situation that may well be worsened by the delays introduced by the additional communication steps in the Hospital at Night approach.

We hypothesized that using newer communication technology in the OOH period would offset delays introduced by the Hospital at Night system, and that this might be demonstrated by a common type of request for urgent review (high EWS) for which guidance on response times exists. The aim of this study therefore, was to compare the medical response time to patients with a high EWS before and after the implementation of a Hospital at Night system supported by wireless technology. As a secondary outcome, we wished to assess if the introduction of the new system affected the nursing decision on whether to escalate a high EWS to the medical team on-call.

Methods

Setting and intervention

This prospective study took place in a university teaching hospital (Glenfield Hospital, Leicester, UK) across three general medical wards before and one after implementation of a Hospital at Night system using wireless technology. OOH care in the pre-intervention group was delivered by the same number of medical staff, but without a nurse coordinator and was organized using a traditional pager and landline system.

In brief, tasks are registered on the wireless system in a standard format using ward desktop computers. These data are transmitted to a nurse coordinators’ tablet computer. This coordinator then allocates tasks to team members as messages containing relevant clinical information in a standard format onto their hospital smartphone, replacing the need for traditional landline/pager systems. Tasks are stored on the phone, replacing handwritten task lists.

Observations

General medical in-patients scoring 4 or more on the Trust’s EWS system (see Supplementary materials) on observations taken between 1700 and 0900 on normal working days or at any time on weekends or public holidays were included in the study.

Data were collected continuously over two 6-week periods throughout 2012–13, by daily manual review of patient observation charts and casenotes. Parameters recorded were: time of observations, EWS, time of junior medical review and time of senior medical review (if applicable). Patient identification was assisted in the post-implementation group by review of the Hospital at Night IT system.

Outcomes

The primary outcome measures was the time taken from the abnormal observations (thus calculation of the EWS) to the documentation of the initial medical review. Secondary outcomes were the proportion of patients with EWS ≥ 4 having a junior medical review, the proportion of those reviews occurring within 30 min (in line with trust guidance, and that of other hospitals), the proportion of patients with EWS ≥ 5 having a senior medical review, the time to senior medical review for patients with EWS ≥ 5 and the proportion of those senior reviews occurring within 60 min (in line with trust guidance). We also investigated if the nursing decision to escalate a high EWS to a medical review (proportion of patients with EWS ≥ 4 having a medical review) was correlated with a marker of workload (the number of patients with an EWS ≥ 4 per shift) or the time in either the nursing or medical shift that the observations were taken.
This study was registered with the hospital audit department.

Statistical analysis

Statistical analysis was performed using SPSS (ver.20.0) statistical software (IBM, USA). Data were tested for normality using the Shapiro–Wilk test. Non-parametric data are expressed as median (IQR) and tested for significance using the Mann–Whitney U-test. Nominal data were tested for significance using the chi-squared test. Data were tested for correlation by calculation of the Pearson’s product-moment coefficient. Overall review patterns before and after the intervention are compared with Kaplan–Meier ‘1-survival’ plots and log-rank test. Significance was set at \( P < 0.05 \).

Results

Case identification

There were 79 instances of patients having an EWS of 4 or more in the pre-implentation phase, and 135 in the post-implementation phase. Of note, 46 of the post-implementation cases were indentified through electronic records but not from the observation charts.

Escalation of high EWS

Throughout the study the majority of patients with an EWS of 4 did not receive a documented medical review (Table 1).

Time to respond: effect of intervention

The time taken to review in response to a high EWS before and after the implementation of the new working method is shown in Table 2. The proportion of patients waiting more than 1 h for review was 49% in the pre-implementation phase and 32% in the post-implementation phase (\( P \) for comparison = 0.092)

Discussion

The primary finding of this study was that the implementation of Hospital at Night supported by a wireless taskflow system significantly improved the time taken for a documented review of patients with a high EWS. These results are in keeping with the time savings seen in a previous study\(^\text{13}\) and are

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Proportion of recorded high EWSs escalated to medical staff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-intervention ( n ) (%)</td>
</tr>
<tr>
<td>Total with high EWS score</td>
<td>79 (100%)</td>
</tr>
<tr>
<td>Patients reviewed</td>
<td>43 (54%)</td>
</tr>
<tr>
<td>Patients with EWS of 4 reviewed</td>
<td>26 (48%)</td>
</tr>
<tr>
<td>Patients with EWS ( \geq 5 ) reviewed</td>
<td>17 (68%)</td>
</tr>
<tr>
<td>Patients with EWS ( \geq 5 ) having a senior review</td>
<td>7 (28%)</td>
</tr>
</tbody>
</table>

Figure 1 illustrates the difference in review patterns before and after the intervention (\( P = 0.091 \) for comparison of survival curves).

Time to respond: effect of magnitude of EWS score

Overall, patients were less likely to receive a medical review if they had an EWS of 4 (43% reviewed) when compared with those who had a higher score (78% reviewed, \( P \) for comparison <0.001). This effect was not seen equally in the pre- and post-phases: In the pre-implementation phase, patients appeared equally likely to receive a medical review whether their EWS was 4 (48% reviewed) or more (68% reviewed, \( P \) for comparison = 0.099). After the implementation of new working practices, a significantly smaller proportion of those with an EWS of 4 were reviewed than those with higher scores: 23 (38%) vs. 60 (81%), \( P = 0.001 \).

Time to respond: effect of timing of observations

No significant correlation was found between either the hour of nursing shift and the percentage of patients with an EWS \( \geq 4 \) receiving a medical review (\( r = -0.118, P = 0.673 \)) or the hour of medical shift and the percentage of patients with an EWS \( \geq 4 \) receiving a medical review (\( r = -0.272, P = 0.326 \)). Neither was the percentage of patients with an EWS \( \geq 4 \) receiving a medical review significantly correlated with the number of patients with an EWS \( \geq 4 \) in an individual medical shift (\( r = -0.118, P = 0.663 \)).
assumed to relate to improved speed and accuracy of communication. If the observed 10-min reduction in response per incident proved accurate, hundreds of hours of patient risk-time could be avoided each year in a hospital. The implementation of the new system did not, however, increase the proportion of individuals who had a documented review within specific set time limits. It may be that these local targets are unrealistic and it is notable that they are not included in national standards.15

In total, there were 1604 requests for urgent patient reviews logged on the electronic system across the whole trust over the 2-month period following the study. If the 10-min time saving is extrapolated to all these tasks, then 1604 h of patient risk-time could be saved across the whole trust in 1 year. Potential cost-savings associated with this system are difficult to assess; it is questionable that a trust would be able to reduce its number of junior doctors and the benefits of this earlier intervention on patient-related outcomes are unclear. However the potential time saving represents the equivalent of taking four junior doctors off the on-call rota, or of paying ~£56 140 on locum shifts (the internal SHO locum rate at our trust is £35 per hour).

It is notable that similar reduction in time to review was not seen with senior reviews. This is likely to arise because the majority of the work handled by registrars comes from outside the wireless taskflow system, either handed over at the start of a shift, as patients are admitted to the assessment unit, or as more junior doctors seek assistance. Thus the majority of their tasks are not expedited by improved communication speed, but this change benefits all the tasks allocated to the junior doctors. Furthermore, the registrars are likely to acquire additional information before making a decision on the timing of a review; they may, for example, feel that the initial junior review instigated an appropriate plan, telephone the ward to confirm improvement, and thus review later.

OOH services in hospital are under increasing strain and are a source of untoward incidents related to errors and omissions. In keeping with this, our study found that a minority of in-patients with a high EWS have a medical review. These findings are consistent with previous studies reporting observations are commonly incomplete and may not be appropriately acted upon:18 for example, a survey of all charts in a UK paediatric hospital found 92% were incomplete.19 Thus our findings are likely to be representative of clinical practice elsewhere. Reasons for this are likely multifactorial, but we did not find any evidence to support the idea that this target is less likely to be met as urgent workload increases, or that it is related to the time during the shift.

Although there is evidence to support some aspects of the use of warning scores,16 there is a lack of guidance around the response to individuals who frequently have a high EWS, such as most admissions with COPD. This type of uncertainty may lead staff to apply additional criteria when deciding who requires review. It is notable that patients with a

### Table 2 Time to medical response to high EWS (≥4) before and after the implementation of Hospital at Night supported by a wireless taskflow system

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to junior review (min) (median(IQR))</td>
<td>60 (38–133)</td>
<td>50 (22–70)</td>
<td><strong>0.010</strong></td>
</tr>
<tr>
<td>Time to senior review (min) (median(IQR)) (patients with EWS ≥ 5)</td>
<td>60 (42–79)</td>
<td>70 (28–188)</td>
<td>0.619</td>
</tr>
<tr>
<td>Number of patients reviewed within 30 min, n (%)</td>
<td>8 (10%)</td>
<td>24 (18%)</td>
<td>0.130</td>
</tr>
<tr>
<td>Number of patients with EWS ≥ 5 having senior review within 60 min, n (%)</td>
<td>4 (16%)</td>
<td>12 (16%)</td>
<td>0.980</td>
</tr>
</tbody>
</table>

Significant result and the main finding of this article is in bold format.

![Figure 1](image-url)  
**Figure 1.** Kaplan–Meier ‘1-survival’ plots comparing time to junior medical review pre- and post-implementation.
higher EWS were more likely to be reviewed in our study. The introduction of newer technologies and the Hospital at Night system have the potential to improve information recording and governance. In this study, we found approximately one-third of cases of patients with a high EWS were recorded on the electronic requesting system but were missed by manual review of observation charts. This may be responsible for proportion of the large difference in the numbers of patients with high EWS scores in the two time periods. This type of finding adds to the literature highlighting the potential of information technology to facilitate research and audit, and casts some doubt on the validity of studies that rely solely on the review of paper records.

This prospective study investigates a common and significant issue using both electronic and paper records. However, we acknowledge the limitations of our relatively small study. Further research will be necessary to establish if the experience at this centre is representative of other hospitals. The adoption of the national EWS may facilitate such multi-centre studies. We also used time to documentation as our proxy of response time and acknowledge that a measure of time to bedside or time to intervention would have been preferable. Further developments in mobile technology will permit such endpoints to be used in the near future.

Conclusion

The implementation of Hospital at Night supported by a wireless taskflow system may significantly reduce the delays in communication caused by the standard landline and pager system, but has no effect on the nursing decision of whether to request medical review.

Supplementary material

Supplementary material is available at QJM online.

Acknowledgements

We are most grateful to Priya Hidelaratchi, Archana Anandaram, Lucy Reynolds, Lucy Murray, Sagaar Mandavia, Jennifer Hutchinson, Emma Muntaz, Bikram Suwal, Jamilia Forest and Ahmadali Sindhi for assisting in the review of observation charts.

Funding

No external funding was sought for this study.

Conflict of Interest: None declared.

References


